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(54) Method of making a bulky multifilament heather yarn, yarn so obtained and carpet containing such a yarn in its pile.

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Description

This invention concerns an improved method for making continuous filament h ather dyeable yarns by cobulking two or more differentially dyeable yarns and improved cobulked heather yarns having enhanced differential dyeability.

Yarns having the appearance provided by many flecks of various colors randomly distributed throughout the yarn are commonly called heather yarns. Heather yarns have long been obtained from random mixtures of differently colored natural staple fibers such as wool by controlling the degree of mixing of the fibers during preparation of the staple yarn. Many methods are now also known in the art for producing heather colored or heather colorable yarns of bulked synthetic continuous filaments by various sequences and combinations of conventional yarn bulking, entangling or intermingling treatments with and without some twisting in the components or in the combined yarn. These methods can be used to obtain a wide variety of products having degrees of heather from very bold, with limited filament intermingling, to very soft or fine, with a high degree of filament intermingling between the components.

For instance, U.S. Patent 3,811,263 (Newton), reissued as Re. 29,352, concerns a method for producing a heather yarn in which major yarn bundles are separately drawn and then combined into a composite yarn by cobulking followed by impacting the yarn with gas streams from a pluralty of jets to randomly entangle portions of the filaments within the yarn. U.S. Patent 3,534,540 (Collingwood et al.) concerns a process for providing a heather dyeable yarn which comprises simultaneously crimping synthetic filaments of at least two differentially dyeable types of nylon followed by entangling of the crimped filaments and then optionally twisting the yarn. U.S. Patent 4,059,873 (Nelson) discloses a process for making a continuous filament heather dyed or dyeable yarn from yarns of crimped continuous filaments of different color or different dye receptivity by tensioning the yarns to straighten crimp and to disentangle the filaments followed by feeding the yarns together into a jet intermingling zone from which the resulting yarn is withdrawn at a rate less than the feed rate of the component yarns to the zone. U.S. Patent 3,854,177 (Breen et al.) concerns a process for texturing yarns of thermoplastic synthetic continuous filaments with a hot compressible fluid and receiving the treated filaments on a moving surface to remove the filaments from the fluid in a substantially tensionless state. The patent discloses that by using a multiple feed of different fiber types, a blend of the fibers in the treated yarn is obtained. A number of feed yarn ends can be used and the resulting yarn may have the ends well blended or separable. Cobulking of filaments of nylon with polypropylene and of nylon with acetate are exemplified.

U.S. Patent 3,971,202 (Windley) does not disclose heather yarns but does concern a method for producing a cobulked continuous filament yarn containing filaments of first and second yarns with the filaments of the second yarn, such as an antistatic component, being frequently located near the surface of the cobulked yarn. That the second yarn may impart some aesthetic quality such as an unusual dye characteristic is disclosed. The method involves drawing the first yarn and feeding it along with a second yarn having a lower shrinkage potential into a hot gas bulking jet to randomly crimp and entangle the filaments of both yarns, thus forming a cobulked yarn in which the filaments of the second yarn are 4 to 20% longer than the filaments of the first yarn.

The present invention relates to improvements in the method and product of the Windley patent adapted to heather yarns.

Bulked continuous filament (hereafter BCF) heather yarns have become quite popular in new styles for carpets. In order to meet the demands of the trade it has become increasingly advantageous to be able to provide a variety of heather effects and BCF yarn counts to the trade. Such product variety calls for a versatile process capable of producing a broad range of heather products and yet capable of competing economically with the many established products and processes known in the art.

For reasons of economy and efficiency BCF carpet yarns are commonly produced by a coupled spin-draw-bulk process as represented and disclosed for example, with respect to Figure 3 in above Breen et al. U.S. Patent 3,854,177. Differently dyeable polymers for BCF heather yarns are commonly spun from separate spinning positions. It is quite expensive to modify a spinning position to co-spin two different polymers; once a position is so modified it becomes less economical to produce a single component yarn therefrom, thus limiting its use. Whereas methods for producing heather yarns which combine previously spun and drawn yarns in the subsequent separate operation are quite versatile with respect to the types of yarns which can be combined, tend to be limited to slower yarn speeds and they require separate facilities and space for the combining operation. Consequently one object of the present invention is an improved method for producing a cobulked heather dyeable yarn on conventional yarn drawing and bulking equipment, and particularly such a method operable at yarn speeds of greater than 1000 meters per minute.

Another object of this invention is a nondirectional heather dyeable BCF yarn having enhanced differential dyeability. Other objects are apparent from the following description of the invention.

Figure 1 is a schematic representation of a preferred embodiment of the method of the invention.

Figure 2 is a partial copy of Figure 1 but shows a different position for the source of the second yarn.

Figure 1 represents a first yarn 1 being extruded at spinneret 2 with quenching by cross flow air at chimney 3. Feed roll 4, and its associated idler roll, at the base of the chimney controls yarn spinning speed and spun yarn denier. The yarn is then drawn across two sets of draw pins 5 and 6 and guided into an enclosure, or insulated ch st, 7 by entrance guide 8. A pair of skewed draw rolls 9 in the enclosure are internally heated and hav a surface speed greater than that of feed roll 4 to impose the desired draw ratio on the yarn 1.

A second yarn 10 having filaments which are differentially dyeable with respect to those of the first yarn and which has been bulked with a hot turbulent fluid prior to being wound on supply package 11 is delivered from over the end of package 11 held on a creel (not shown) and passes through guide 12 and transport tube 13. A ceramic guide 14 is provided on the lower end of the tube to reduce wear and minimize tension buildup. Guide 15 is positioned to keep the first and second yarns separated in planes, both parallel and perpendicular, to the plane of the drawing, as they approach rolls 9. The two yarns remain separate from one another and both yarns are wrapped 9-1/2 times on the pair of rolls 9. The yarns then pass together from enclosure 7 into chamber 17.

In chamber 17, bulking jet 18 forwards the combined yarns simultaneously in a high velocity stream of hot turbulent fluid such as air or steam in a confined space to randomly crimp, shrink and randomly comingle the filaments and deposit them in a cobulked crimped condition under low tension on the screen surface of drum 19 moving at a much slower speed than that of the forwarded yarn. The filaments are cooled while on the screen, optionally with a liquid mist (not shown); then take up roll 20 pulls the cobulked yarn 24 off of drum 19 and around guide 21. The yarn then passes guide 22 to a windup (not shown) which applies sufficient tension to wind the yarn into a firm stable package 23.

Figure 2 shows Figure 1 in part but with second yarn 10 coming from package 11 on a creel (not shown) which is at a level below rolls 9. Yarn 10 proceeds to guide 15 without any interfloor tube as in Figure 1. The other components are the same as in Figure 1.

This invention provides an improved composite cobulked continuous filament yarn containing a first oriented continuous multifilament yarn which has been bulked in a hot fluid jet process simultaneously with a second oriented continuous multifilament yarn, the filaments of both yarns being randomly intermingled throughout the length of the composite yarn and having random three-dimensional curvilinear filament crimp with frequently alternating regions of S and Z filament twist, the filaments of said second yarn being at least about 4% longer in said composite yarn than the filaments of said first yarn, wherein the improvement comprises: the filaments of said first and second yarns being of polymers containing the same type of chemical dye sites with the filaments of said second yarn having a substantially greater concentration of said dye sites in equivalents per unit weight of polymer than the filaments of said first yarn thus providing differential dyeability. Preferably, the filaments of said second yarn are from about 4% to about 20% longer than the filaments of said first yarn, and more preferably from about 4% to about 10% longer. This difference in filament length relates not only to a consequential degree of filament intermingling between the yarns but also to consequential differences in tensile properties between filaments of the two yarns; in addition to an enhancement in differential dyeing properties which can be realized by this invention.

The filaments of said first yarn comprise from about 25% to about 75% of the total weight (or denier) of said first and second yarns in order to provide the desired heather and multicolor effects upon differential dyeing. This proportion of yarns is also needed to realize the benefits of the first yarn becoming the load bearing component in the cobulking step which load bearing is believed to contribute to the enhanced differential dye effects and the resulting differential filament tensile and crimped properties in the cobulked product.

The enhancement in differential dyeing qualities of the invention is particularly effective when the polymers on said first and second yarns are polyamides, i.e., nylon, in which the chemical dye sites of interest are the polymer amine end groups. The enhancement occurs when the concentration of such dye sites in said first yarn is less than that in said second yarn; whereupon the invention provides a greater difference in dyeability or dye-stepping between the two yarns when dyed competitively than is provided by such yarns when bulked individually under comparable conditions. This enhancement is particularly significant when the first polyamide yarn contains cationically dyeable sulfonate dye sites and the second yarn is a polyamide of regular or deep acid-dyeing capability as determined by the concentration of amine ends with respect to the carboxyl end groups in the polymer as known in the art. The invention then results in less staining of the cationic dyed yarn by acid dyes, thus enhancing the differential dye effect between the cationically dyed filaments and the acid dyed filaments.

Apparently as a result of the differential change in filament lengths during the cobulking step, the load bearing filaments of the first yarn tend to have lower crimp and a greater tenacity, modulus and toughness than filaments of the second yarn in the final cobulked yarn. However, these differences do not interfere with overall desirable bulk, tensile properties and performance of the cobulked yarn.

This invention also provides a method of producing a composite cobulked continuous filament yarn containing filaments of a first oriented continuous filament yarn and of a second oriented continuous filament yarn in which the filaments of said second yarn are longer than the filaments of said first yarn said method including the steps of (1) feeding said first yarn in an undrawn state at a controll d speed to a pair of heated draw rolls, (2) wrapping said first yarn around said draw rolls a

sufficient number of times to avoid slippage thereon and said rolls being driven at a surface speed at least twice the feeding speed of said first yarn thereby applying tension to and drawing to mol cularly orient said first yarn, (3) also feeding to said pair of draw rolls from a yarn package at a tension of less than 0,88 dN/tex (1.0 grams per denier) said second yarn having a lower shrinkage potential in a hot gas bulking jet than said first yarn, (4) wrapping said second yarn around said draw rolls to prevent slippage thereon, (5) bringing said first and second yarns together and forwarding the combined yarns in a high velocity stream of hot turbulent fluid in a confined space which randomly crimps and entangles the filaments thereof and thereby forms a composite cobulked yarn in which the filaments of said second yarn are at least 4% longer than the filaments of said first yarn, (6) removing the cobulked yarn from the stream of hot fluid and cooling it at low tension while the filaments are in a crimped condition to set crimp in the filaments and (7) winding the cobulked yarn into a package under tension, the improvement for making a heather dyeable yarn comprising: feeding to said draw rolls as said second yarn heat-relaxed yarn containing crimped filaments which filaments are differentially dyeable with respect to the filaments of said first yarn and which filaments constitute from about 25% to about 75% of the total weight of the cobulked yarn. It is preferred that the second yarn be fed from a package to the draw rolls at a tension that is less than about 0,44 dN/tex (0.5 grams/denier).

Little advntage is provided by having a differential change in length between the first and second yarns of greater than about 20%. Preferred results are realized when the differential change in length between the first and second yarns is within the range of from about 4% to about 10%.

The method is capable of being operated at high yarn speeds. Because of the advantages in productivity it is particularly useful when operated at 1,000 meters/minute and above. Such high speed is also suitable for coupling the method with a spinning process such that the first yarn is fed from a spinning zone directly to the draw zone of this invention.

The term "heather dyeable" as used herein refers to a yarn which under cross-dyeing conditions (commonly used in the trade to obtain multiple colors from a single dye bath) becomes differently colored in a random manner to give numerous flecks and spots of specific colors dispersed among blended regions of those colors along the yarn. The term also is intended to include the use of differentially pre-colored component yarns, for instance spun-dyed, since they are inherently differentially dyeable whether colored additionally or not.

Where reference is made herein to a first yarn and to a second yarn, unless indicated otherwise, this does not exclude additional yarns which may or may not be differentially dyeable with respect to each of the first and second yarns. Also each first and second yarn may consist of more than one yarn end to provide a greater first or second yarn denier where desired.

In order to achieve a multicolor effect now popular in the carpet trade, the first yarn of this invention should comprise at least about 25% and no more than about 75% of the denier or weight of the resulting composite yarn.

Conventional hot fluid jet yarn bulking processes may be used for the cobulking step in the method of this invention. In such processes a yarn comprised of plasticizable filaments is bulked with a compressible fluid heated to a temperature which will plasticize the filaments. The bulking imparts a persistent crimp having a random, three-dimensional, curvilinear, extensible configuration continuously along the filaments. The yarn is fed into a high velocity stream of the hot turbulent fluid in a confined space at a speed which is greater than that at which it is withdrawn from the fluid, commonly by an overfeed amount of from about 10 to 200%, preferably more than about 30%. The crimped filaments may be allowed to cool freely in air, or in a cooling chamber as with a so-called stuffer-jet, or on a moving surface which is permeable to the fluid and separates the filaments therefrom. Such processes are particularly effective for crimping melt-spun synthetic polymeric filaments commonly used in commercial yarns, e.g., nylon, polyester, and polypropylene filaments. The bulked filaments in addition to having the random three-dimensional curvilinear crimp also have a randomly varying twisted configuration along the filament axis with portions in an S direction and alternate portions in a Z direction which provides outstanding bulk and aesthetics. Such twist is characterized by frequent portions of twist where the twist angle with respect to the filament axis is greater than 5° and which may be as high as 30°. Since the twist configuration of each filament varies randomly along its length the yarn made up of a group of these filaments, particularly if the filaments are of a nonround cross section, is prevented from packing in a closely nested configuration resulting in increased bulk even under compression. The character of such filaments is described in greater detail in U.S. Patents 3,186,155 and 3,854,177, to Breen et al. A preferred bulking method for this invention is the jet-screen bulking method as described in U.S. Patent 3,854,177 because of its ability to run at high yarn speeds of greater than 1,000 meters/minute. This method is particularly preferred when used in combination with a yarn-treating jet apparatus of the type described in U.S. Patent 3,638,291 (Yngve) or 3,525,134 (Coon). Such jets are preferred for their efficiency and effectiveness at high speeds and for providing the desired uniformity, degree of bulk and filament intermingling without undesirable filament loops.

In the composite yarn products of this invention, the filaments of each component yarn are crimped and they are intermingled and entangled not only with other filaments of the same component but also in varying degrees with filaments of oth r component yarns (comingled). The filaments will not

be entangled to the same degree in each yarn component. For example, because of the nature of the process the filaments of the first yarn will be less intermingled and entangled with one another than those of the second yarn, which have been previously subjected to a hot turbulent fluid bulking process and which provides some initial filament entanglement. This combination of entanglement among and between filaments and components provides a coherent yarn structure which is suitable for being handled directly by conventional textile machinery, and by carpet tufting machines in particular.

The method of this invention is particularly suitable for the preparation of heavy denier bulked continuous filament yarns within the range of from about 1500 to 5000 total denier (about 167 to 556 tex) and composed of two or more, preferably no more than three, differentially dyeable yarn components. In carpets, filament deniers within the range of 6 to 40 (6,67 to 44,4 dtex), and particularly 15 to 25 (16,7 to 27,8 dtex), are preferred because of the performance and aesthetics desired by the trade.

When combining a coupled spun and drawn yarn by this invention with a creeled yarn, the yarn components in the final product have different degrees both of true yarn twist and of filament entanglement. The first yarn is free of true twist and is free of any significant filament entanglement as it is supplied to the preheating zone, i.e., the draw rolls. The second yarn, and additional yarns fed in the same manner, has a low level of true twist imparted by taking the yarn off the end of a creeled yarn package, thus imparting one turn of twist for each length of yarn making one circumference of the package. This true twist is normally in the range of from about 1.0 to about 3.0 turns per meter and remains in the component in the combined yarn. This difference in twist possibly contributes to the desirable heather aesthetics achieved by this invention.

A preferred embodiment of the invention because of the good bulk and desirable heather obtained is one in which there is a difference in filament length between component yarns of at least 4%. This difference in length results from the differential change in length between the first and second yarn due to tension differences and to the previous hot fluid processing of the latter which results in its shrinking less during the cobulking step than the freshly drawn component. This difference in filament length is believed to aid in mixing of the filaments within the overall combined yarn bundle and to facilitate random cyclic surfacing of filaments along the yarn as well as to enhance dyeability differences under certain circumstances as described herein.

To retain the desired heather blending and to provide sufficient yarn coherency for processing, the cobulked yarn preferably has a cohesion as measured on automatic pin drop testing equipment (APDC) test of from 1.0—6.0 cm. This moderate level of cohesion allows greater bulk than that of some present commercial heather yarns of similar aesthetics and mixing which are produced by combining previously bulked yarns in an air jet at ambient temperature, as described for example in U.S. Patent 4,059,873 (Nelson). The method of this invention provides substantially equivalent heather effects with less restrictive entanglement resulting in improved bulk in the final product. This improved bulk is observed for example in the products of this invention having a bundle crimp elongation (BCE) within the range of from 30 to 60%.

The products of this invention also can display improved package delivery characteristics over similar commercially available yarns having substantially similar heather properties and differential filament lengths in the yarn. Poor delivery of yarn from a package with erratic tension can produce breaks in the yarn or streaks in a carpet after tufting. Upon comparing three yarns of this invention to a control yarn prepared by combining previously bulked yarns with an air jet as described in the following paragraph, yarns of this invention gave from 3 to 20 times fewer package delivery plucks in the critical tension range of greater than 500 grams (where such high tensions can produce carpet nonuniformities).

As already mentioned, yarn bulk as measured by BCE can be substantially higher for the subject yarns than prior art yarns produced in a split process of bulking the individual yarns followed by combining the bulked yarns. For instance, a two component split process heather (control) yarn processed with a 6% overfeed in one yarn component with respect to the other and otherwise generally as described in U.S. Patent 4,059,873 had a BCE after boil-off of 21.2% versus greater than 50% for a similar item prepared by this invention. This improved bulk can be used to provide adequate cover at lower carpet weights.

Whereas in a preferred embodiment of this invention the second yarn is supplied from a creel at a tension of less than about 0,88 dN/tex (1.0 grams/denier), tensions greater than this can be applied to assist in removal of filament entanglement from the creel yarn and to increase the retraction of the yarn in the cobulking zone. Also, shrinkage of the freshly drawn first yarn component can be reduced by decreasing the mechanical draw ratio in the draw zone. By adjusting the relative shrinkages and retractions of these yarns in the cobulking zone, it is possible to provide a variety of effects as desired. Any desired combination of tension on the second yarn and draw ratio on the first yarn can be obtained through the use of separate or stepped rolls to control the yarn feeds to the preheating rolls. Attractive yarns can be produced in this manner over a broad spectrum of heather effects from relatively bold to soft.

The method of this invention comprises supplying an already bulked continuous filament second yarn, having a different dyeability or color with r spect to a first yarn, into a common preheating zone

and cobulking the second yarn with the first (unbulked) yarn in a coupled spin-draw-bulk process for manufacturing the first yarn. T sts show that the bundl cohesion and filament entanglement of the s cond yarn is reduced in the preh ating step prior to the cobulking step. For example, using a method as represented in Figure 1 with the draw rolls 9 being heated at 210°C the coherency of th second yarn prepared by the method generally described in U.S. Patent 3,854,177 changes from about 3.0 centimeters to about 10.0 centimeters APDC depending on the yarn tension of the second yarn arriving at the draw roll. Measurements of coherency on the first yarn from samples taken prior to cobulking show considerably less cohesion, for example greater than 28 cm. APDC. The spun yarn normally has a much higher shrinkage potential due to its high tension and orientation from drawing while the creeled yarn has already been relaxed in its previous bulking process.

The second yarn may be provided from a creel located in any convenient location such as from a second floor above, as represented in Figure 1, or from a lower position than the draw rolls whereupon it is merely guided to substantially the same point for feeding onto the draw rolls in any convenient manner as represented in Figure 2. The yarn may be passed from one floor or level to another by means of a grounded metal interfloor tube as shown in Figure 1 with a ceramic exit guide made from known aluminum-silicon-magnesium ceramic material commonly used in yarn guides. In general, low friction change of direction guides can be used as necessary to control the yarn prior to its arriving at the draw rolls. Best operability has been found to occur when the creeled second yarn is maintained slightly separate from the spun-drawn first yarn on the heated rolls.

The amount of yarn overfeed between the draw rolls and the take-up roll following bulking, e.g., rolls 9 and 20 in Figure 1, as determined by the differences between the respective roll surface speeds, is a key parameter relating to combined yarn bundle structure, yarn properties and resulting carpet appearance. It has been found that when conventional BCF nylon yarns are reprocessed alone through a "re-bulking" step very limited overfeeds are operable, for example, a maximum of only about 10%. Attempts to run at higher overfeeds result in unstable operation with difficulty in controlling the yarn on the screen. This low limit of overfeed is related to the low shrinkage potential of the previously jet treated yarn. The spun-drawn yarns by themselves have a much higher shrinkage potential upon undergoing the bulking operation and normally operate satisfactorily at overfeeds up to as high as 35% or more. With yarns having a maximum overfeed of 10% for the second yarn alone and 35% for the first yarn alone, the process of the invention is found to operate satisfactorily at an overfeed of up to 22%. Apparently the higher shrinkage force of the spun yarn tends to overfeed the lower-shrinking second yarn while stabilizing its operation. Since the second yarn has the higher coherency it tends to form a wandering core component which alternates with excess length along the cobulked yarn through the less cohesive bundle of filaments of the first yarn. This combination of the two yarns results in a tendency for the filaments of the first yarn to frequently appear on the surface of the combined yarn, even though they can be shorter, and at times completely surround the more cohesive second yarn with an open sheath network of filaments through which the second yarn can still be seen.

The maximum overfeed operable in the process is dependent upon the temperature of the draw (pre-heating) rolls. As the temperature is increased in general, the overfeed can be increased. For example, in one test whereas a conventional 66-nylon carpet yarn as the second yarn was limited to 6.5% overfeed at a chest roll temperature of 190°C, processed alone, the overfeed could be increased to 10.6% at 210°C roll temperature.

Increasing tension on the creeled yarn as it enters the preheating zone also tends to increase maximum operable overfeed with the effect being ..eater at higher roll temperatures.

Similarly, the maximum process overfeed is affected by draw ratio. As draw ratio is reduced at constant denier, the maximum overfeed is reduced and the difference in filament length of the second yarn with respect to the first yarn is proportionately lower. In other words, the relative length of the spun-drawn yarn filaments increases due to lower shrinkage in the spun-drawn yarn because of lower orientation and retraction as the draw ratio is reduced. For instance with 66-nylon at draw ratios below 1.8× the spun-drawn filaments have been observed to become longer than the creeled yarn filaments, even when the latter are supplied under low tension.

Tests run at a series of draw ratios with other process variables held constant show maximum bulk and color mixing occurring at a conventional high draw ratio of 3.0× with increasing boldness and reduced bulk being realized as the draw ratio is reduced.

With yarns of 66-nylon, preheating roll temperatures in the range of 190—215°C have provided highly satisfactory results. In general, higher bulk based on subjective carpet assessment and by the BCE test is realized at the higher end of the temperature range. This higher range, e.g., 210—215°C, produced highly attractive heather.

The creeled second yarn can be subjected to high tension, such as greater than 1 gram per denier, to achieve more intimate blending of the component filaments. To help minimize yarn breakage under such conditions it is preferred to lengthen the zone in which the tension is applied in order to provide time for the filaments to disentangle themselves and become more equally aligned to bear the load. Cobulking of a highly tensioned creel yarn and a partially drawn spun yarn results in softer more highly blended heather yarns with much reduced boldness in carpets.

The method of this invention provides an easy route to substantially reduce the manufacturing

cost of, and to increase production facilities for, bulked heather yarn products with little additional investment and through the use of existing coupled bulking process machinery.

The method provides yarns of uniform bulk and can provide a relatively constant BCE over a relatively wide rang of preheat tempeatures, creel tensions and draw ratios which is desirable from the standpoint of process control.

The use of the bulked yarn as a supply for the second yarn results in advantages compared to the method disclosed in U.S. Patent 3,971,202 (Windley) in which the second yarn is a flat yarn, i.e., not bulked. Such advantages include high bulk and good process operability of the combined yarn, in spite of the limited maximum overfeed caused by the low shrinkage of the bulked second yarn. Use of a bulked second yarn also results in fewer yarn breaks from the creel at high speed than with drawn flat yarns as the second yarn, particularly at speeds of greater than 1,000 meters/minute. The discovery that conventional commercial coherent bulked continuous filament carpet yarns can be used as the second yarn without special treatment or preparation, such as disentangling, eliminates the need to prepare special bulked or flat yarns as the second yarn (in a yarn manufacturing facility normally equipped to produce bulked yarn products) thus minimizing costs.

The method of this invention is particularly useful for producing heather carpet yarns of low deniers in the range of about 1800 to 3500 (200 to 389 tex) because of its improved economics. Where separate facilities are required to make heather yarns, efficient use of such facilities favors the production of heavier denier yarns. Also, the improved bulk which can be realized by this invention provides good cover with light denier yarns further facilitating their use in light carpet constructions. The economics of the invention particularly favor the production of two color yarns, that is ones with only a first and second yarn. For nylon yarns, a preferred combination because of its versatility and appeal to the trade is the use of a cationically dyeable nylon with a deep acid dyeable nylon component. In this case it is preferred that the cationically dyeable yarn be the first yarn, i.e., the live spun-drawn component. Using the more dye sensitive deep dyeing yarn as the second yarn permits dye control testing prior to its being incorporated into the combined yarn helping to reduce waste.

The second yarn of this invention may itself be a cobulked yarn containing a third component such as an electrically conductive yarn to provide an antistatic effect to the cobulked yarn of this invention. The conductive yarn may be of the type described by Hull in U.S. Patent 3,803,453 which has been introduced into the second yarn of this invention using the cobulking process of U.S. 3,971,202 (Windley).

The enhanced differential dyeability, e.g., between cationic and acid dyeable nylon filaments, obtainable by this invention can be used to economic advantage by employing a (less expensive) acid dyeable component having fewer amine ends than normal. For instance, a conventional regular acid dyeable 66-nylon BCF yarn when processed by the invention as the second yarn along with a cationic dyeable first yarn is found to be equivalent to a combined cat-dyeable and deep-acid dyeable yarn made using an ambient air jet to combine the previously bulked yarns; i.e., no significant shade difference is seen in carpets of these two yarns after cross-dyeing. The enhancement realized by the invention under such circumstances is equivalent to about 20 to 30 additional amine end groups in the acid-dyeable component. Expressed in another way, the process of this invention increases dye stepping between the first yarn and the second yarn by an average factor of about 1.5x when the fibers are dyed under mild conditions such as at low temperature and/or short holdup times.

This enhancement is due to a differential change in fiber structure between the component yarns, beyond their chemical dyeing characteristics. For example, a combination of cationic and regular-acid, or light-acid with regular-acid dyeable yarns prepared by the invention about equal the dye stepping of conventional cationic and deep-acid, or light-acid and deep-acid combinations, respectively, when the latter are made by conventional intermingling processes. This increased dye stepping can be diminished by leaving the dyed yarns in the dye bath longer than necessary to complete the dyeing; so care must be taken in selecting dyeing conditions when maximization of the effect is desired.

Because of this dye enhancement, yarns made by this invention can be dyed at a lower temperature or with shorter heating cycles to save energy. For example, in a Beck process, yarns of the invention were uniformly dyed in a cycle with the steam heating being on for only about 75 minutes versus 130 minutes for a standard cycle.

This improved dyeing is observed regardless of the dyeing type of nylon polymer employed (such as cationic, light-, regular- or deep-acid), of filament cross section, of filament draw ratios above about 2.0x, and of bulking fluid (superheated steam versus air). This enhancement however is significantly affected by tension on the second yarn as it is fed to the common draw roll. The dye stepping advantage diminishes as the creel tension is increased and becomes small when the tension is above about 1.0 gpd (0.9 dN/tex). It is preferred however to keep the creel tension on the second yarn below about 0.8 gpd (0.7 dN/tex). The best dye stepping is obtained at the lowest creel tension consistent with good process operability.

It is speculated that the enhanced differential dyeing provided by this invention depends to a considerable degree on the tension in the yarns between the draw roll and the bulking jet. This tension, commonly about 0.08 gpd (0.07 dN/tex), is provided by the forwarding action of the jet as necessitated by yarn overfeed to provide bulking. The jet pulls both the spun (first) yarn and the creeled

(second) yarn away from the draw r ll. The spun component shrinks much more than th cr eled component upon leaving th draw rolls since it has been under drawing tension and has not y t been heat-relaxed as has the creel d yarn. Since the two components become entangled in the bulking jet, the creeled component cannot be pull d away by the jet any faster than the spun component, so it apparently goes slack between the draw roll and the bulking jet. Therefore, the pull or tension xert d on the creeled component by the jet is transferred to and borne by the spun first yarn, which therefore sees much greater tension than it would in the absence of the second yarn. This premise is consistent with the observation that the tenacity and modulus of the spun yarn are generally higher than they would be in the absence of the second yarn under equivalent conditions otherwise. Conversely, the tenacity and modulus of the creeled components are usually lower than that of the yarn before being "re-bulked".

In a screen bulking process, when the cobulked yarn of the invention is removed from the screen and placed under tension for winding, the shorter filaments of the first yarn are subjected to the entire winding tension. Therefore the winding tension on the first yarn will usually be higher than if produced alone. This winding tension tends to straighten and at least temporarily reduce crimp. Whereas this tension normally is not sufficient to destroy crimp, the crimp count frequency of the filaments of the first yarn may be reduced somewhat more than those of the second yarn. Consequently, excessively high tension during winding, which could permanently remove crimp and crimp recovery potential in the final yarn, should be avoided.

Contrary to the behavior of conventional plied intermingled yarns, in which one yarn component is the load bearing member and when under load tends to migrate to the center of the combined bundle, the filaments of the first yarn of this invention become entangled with and about the second yarn or yarns before such tension is applied. Thereafter, they are not free to migrate to the yarn center. It has been observed in yarns of the invention that in regions where the filaments of the first yarn surround the second yarn, tension on the composite yarn causes filaments of the first yarn to compress the longer filaments of the surrounded second yarn; which action can facilitate handling of the yarn such as making it easier to be inserted in a carpet backing during tufting or to be removed from a yarn package.

When operating at high yarn speeds such as greater than 1500 ypm (1371 mpm), to avoid sloughing of the creeled (second) yarn from an almost empty yarn tube when the yarn supply is transferring via a transfer tail to a new full yarn package it is desirable to use yarn tubes which have their surface coated with colloidal silica, such as "Ludox" colloidal silica (E. I. du Pont de Nemours and Company) for increased friction. For example, a 30% aqueous silica dispersion can be applied to the tube either by spraying or by dipping, followed by drying. The friction has been found to be sufficient when it will prevent a single tube from slipping when stacked on two side-by-side similarly coated tubes which are tilted at an angle of 30° to horizontal.

Unless otherwise specified, the following test methods were used to obtain data as reported herein. For some methods the yarn is conditioned prior to testing. Unless otherwise specified, when conditioning is called for it means that the sample is exposed for at least 2 hours in air at 21±1 °C and 65% relative humidity just prior to testing.

Yarn denier is measured by removing the yarn from a package and slowly winding it on an 18 cm. long piece of cardboard with negligible tension. The yarn is aged at ambient room conditions for at least one week and then conditioned just prior to denier measurement. For the measurement, the sample is removed from the card, suspended on a vertical 90 cm. long cutter, loaded with a specified weight for at least three minutes for yarns having a denier no greater than 1900 (211 tex), and for at least six minutes for yarns having a denier above 1900 (211 tex), and then a 90 cm. length of yarn is cut. The specified weights are: 62 grams for yarns of no greater than 1,000 denier (111 tex), 125 grams for yarns of greater than 1,000 (111 tex) and up to 2,000 denier (222 tex), and 280 grams for yarns of greater than 2,000 denier (222 tex). The cut sample is then weighed on an analytical balance. The weight of the sample in grams measured to 4 significant figures is multiplied by 10000 to give the denier of the sample. Normally denier is given as the average of three such measurements.

Tensile properties of tenacity, elongation-at-break, initial modulus and toughness, before or after boil-off, are measured in the conventional manner using a tensile testing machine such as an "Instron" TM-1130 stress-strain analyzer having an automatic recorder and equipped with the appropriate load cell and air-operated clamps for holding the sample. The equipment is set for a 15.24 cm. sample length between the clamps and at an elongation rate of 100% per minute (i.e., 15.24 cm./min extension rate). For testing, the yarn sample is twisted 1.18 turns/cm. The values in grams/denier are calculated in the conventional manner.

Bundle crimp elongation (BCE) is the amount a boiled-off, conditioned yarn sample extends under 0,088 dN/tex (0.10 grams/denier) tension, expressed as percent of the sample length without tension. A 50 cm. length (L_1) of the test sample in a relaxed condition is mounted in a vertical position. The sample is then extended by gently hanging a weight on the yarn to produce a tension of 0.088±0.017 dN/tex (0.10±0.02 gram/denier). The extended length (L_2) is read after the tension has been applied for at least three minutes. BCE, in percent, is then calculated as $100\ (L_2-L_1)/L_1$. Results are normally reported as averages of three tests per sample.

Crimp frequ ncy and filament crimp index are determin d using a 1500 mg. capacity Roll r-

Smith analytical balance (Biolar Corporation of North Grafton, Massachusetts). Crimp frequency is defined as the number of crimps per xtended length in centimeters of a boiled-off, conditioned fiber while under 17,65 dyn/tex (2 mg/denier) t nsion and the extended length being measured under 0,0441 dN/tex (50 mg./den) tension. A crimp is considered to be one complete crimp cycle characteristic of the samples crimp form (e.g., sinewave or helical turn). Filament crimp index is the difference in length of a boiled off, conditioned fiber measured (a) with 17,65 dyn/tex (2 mg./den) tension versus (b) with 0,0441 dN/tex (50 mg./den) tension, and is expressed as a percent of the extended length at 0,0441 dN/tex (50 mg./den) tension. The balance is equipped with (1) a 100 mg. clamp hanging from the balance beam and (2) a vertically movable clamp, called a "transport" that has an associated vertical transport scale which permits measurement of the extension of the fiber to within 0.01 cm. The transport is adjusted so that the transport clamp and balance clamp just touch one another whereupon the vertical transport scale is read (R_0). The fiber sample is then mounted in the balance clamp and transport clamp, with the clamps positioned approximately 2 cm. apart. The transport clamp is then moved until the fiber is under 17,65 dyn/tex (2 mg./den) tension. The transport scale is then read again (R_1) and the number of crimps (N) is counted with the aid of a 2× magnifying glass. The transport is then moved until the tension is 0,0441 dN/tex (50 mg./den) and the transport scale read again (R_2). Crimp frequency is calculated as $N/(R_2—R_0)$ and filament crimp index is calculated as $100(R_2—R_1)/(R_2—R_0)$. The results are normally reported for the average of 20 fibers per sample.

Percent filament length difference (%FLD) after boil-off (ABO) is determined by placing one or more two-meter lengths of coiled yarn in a closed perforated stainless steel cup. The cups are then loaded into a pot containing a solution of H_2O at ambient temperature (~25°C) containing 1% (of the skein weight) "Alkanol" ACN wetting agent, 1% "Sevron" Red L (cationic) dye and 1% "Anthraquinone" Milling Blue B (acid) dye (for cat- and acid-dyeing nylon respectively). The solution is adjusted to 6.2 pH, brought to a boil, and maintained at boiling temperature for five minutes. The yarn cups are carefully removed and rinsed to clear H_2O at ~25°C, then extracted via centrifuge and dried on a flat pan in an oven at 125°C for one hour. The yarn cups are then placed in an ambient (18—27°C) storage area and cooled for one hour. A knot is tied about one meter from the end of each sample, and a first weight of 0,45 grams per tex (0.05 grams per denier) is attached to the other end. The knotted end of the sample is attached to a clamp more than 2 cm. above the knot and the weighted sample is allowed to hang vertically for five minutes. It is cut 88 cm. below the knot and 2 cm. above the knot, both positions being determined while the sample is hanging with the weight attached. A dissecting needle is then used to separate the filaments of the spundrawn (first) yarn from the combined yarn near the end remote from the knot. The ends of these filaments are aligned and the terminal 1 cm. of one filament is trapped between the adhesive sides of a folded piece of tape. The knot is then clamped to the top end of a vertical measuring device calibrated in centimeters. A weight of 1,8 grams per tex (0.2 grams per denier) is then attached to the folded tape. An operator supports the second weight in one hand and uses the other hand to slide the majority of the combined yarn upward along the spun-drawn filament in successive steps to within 15 cm. of the knot. The majority of the combined yarn is then slipped downward to 40 cm. from the knot, being careful not to stretch the spun-drawn filament. The weight is then allowed to hang freely, and the position of the top of the folded tape is measured within 5 seconds. The length of the spun-drawn filament is then recorded as "Spun-Drawn Filament Length" (cm.). Generally five filaments are tested and the results averaged and identified as "Average Spun-Drawn Filament Length" (cm.). The same procedure is then performed on the creeled (second) yarn filaments which are identified as "Average Creeled Yarn Filament Length" (cm.). "Percent Filament Length Difference" is calculated by the formula below.

Percent "Filament Length Difference" can be measured on two-component yarns before boil off by staining the cationic component in ambient temperature (25°C) Sevron Red L dye solution followed by air drying at ambient temperature prior to cutting the yarn sample. The preferred practice is to utilize the "After Boil Off" procedure which most nearly simulates the yarn treatment in finished carpets.

$$\%\ \mathrm{FLD} = \frac{\text{Length (cm) of Creeled Yarn Filaments} - \text{Length (cm) of Spun Yarn Filaments}}{\text{Length (cm) of Creeled Filaments}} \times 100$$

Relative Viscosity (RV) is the ratio of the absolute viscosity of a solution of 8.4 wt. percent 66-nylon or 6-nylon (dry weight basis) dissolved in formic acid (90% formic acid and 10% water) to the absolute viscosity of the formic acid solvent, both viscosities being measured at 25±0.1°C. Prior to weighing, the polymer samples are conditioned for 2 hours in air at 50% relative humidity.

Yarn cohesion is measured using an automatic pin drop counter (APDC) of the type described and claimed in U.S. 3,290,932 (Hitt) with modifications as described in U.S. 3,563,021 (Gray) at Column 15, line 70 through Column 16, line 12. The apparatus is adjusted to give a tension on the yarn between the needle and the drive roll of 29,4±4,9 cN (30±5 grams). The tension required to tilt the needle holder assembly is 78,45±4,9 cN (80±5 grams).

Example 1

This example represents a preferred embodment of the invention in which the first yarn is a cationically dyeable yarn of 66-nylon and the second yarn is a bulked deep acid dyeable yarn of 66-nylon.

The yarns are cobulked in a process arrang ment as represented in Figure 1 except that the location of the supply package for the second yarn is located in the alternate position of 11′ below rolls 9. The first yarn is of a conventional 66-nylon, poly(hexamethylene adipamide), polymer chemically modified to impart cationic dyeability and having a relative viscosity of 59. The yarn is spun from so-called "bright polymer" containing less than 0.03% of titanium dioxide as a delusterant. The yarn contains 68 filaments of about 21,1 dtex (19 denier) per filament after drawing. The filaments have a symmetrical trilobal cross section with a modification ratio of 2.3. The filaments are spun at a temperature of about 290°C and quenched with air in a conventional manner. An aqueous finish is applied by means of a finish roll (not shown) just prior to feed roll 4. Feed roll 4 controls the spun yarn speed at 457 meters per minute. Draw rolls 9 have a surface temperature of 210°C and a surface speed of 1376 meters per minute giving a draw ratio of 3.0x. With 9-1/2 wraps on rolls 9 yarn 1 is preheated and advanced to jet 18 of the type described in U.S. 3,638,291. Jet 18 is supplied with air at 245°C at a pressure of 1317 kPa (12.0 atm. gauge).

The second yarn is 66-nylon which is deep acid dyeable from a high concentration of amine ends, semi-dull luster due to 0.15% titanium dioxide, and is a bulked coherent yarn having been bulked by a plasticizing hot turbulent fluid in the manner described in U.S. 3,854,177 (Breen et al.) using an air temperature of 185°C. This yarn has a denier of 1350 (150 tex) and contains 68 filaments with a symmetrical trilobal cross section having a modification ratio of 2.3. The yarn before boil-off has a tenacity of 3,09 dN/tex (3.5 grams/denier), an elongation at break of 37%, an initial modulus of 9.9, and a coherency of 3.61 cm. APDC. After boil-off the second yarn has a denier of 1383 (154 tex), a tenacity of 3,02 dN/tex (3.42 gpd), an elongation of 47%, a modulus of 6.51, a boil-off loop shrinkage of 3.44, a BCE of 32.8%, a crimp frequency of 1.46 cm^{-1}, and a filament crimp index of 16.12.

Rolls 9 have a surface temperature of 210°C and a surface speed of 1376 meters per minute. The two yarns are kept separate from each other as they arrive at rolls 9 by adjusting the position of guide 15. Tension on second yarn 10 between guide 15 and rolls 9 ranges between 98 to 196 cN (100 to 200 grams; 0,062 to 0,132 dN/tex; 0.07 to 0.15 grams per denier) due to variation in drag of yarn 10′ across the surface of supply package 11′. Second yarn 10′ is also preheated by rolls 9. Both yarns pass with 9-1/2 wraps on rolls 9 and are advanced to jet 18. The combined cobulked yarn is removed from jet 18 by a moving screen on drum 19 with a surface speed of 55.0 meters/minute and is held on the screen by a vacuum inside the drum. Take up roll 20 with a surface speed of 1105 meters/minute removes the cobulked yarn from the screen and advances it to windup 23 where it is wound a tube at 1178 meters/minute.

All the filaments of the resulting cobulked yarn have random, three-dimensional curvilinear crimp with alternating regions of S and Z filament twist with frequent twist angles of greater than 5° with respect to the filament axis. The filaments of the first yarn are observed to be generally less coherent than those of the second yarn and are frequently located along the surface of the cobulked yarn bundle.

Before boil off the cobulked yarn has a denier of 2934 (326 tex), tenacity of 2,11 dN/tex (2.39 grams/denier), 49% elongation, 4.66 modulus, and 1.65 cm. APDC. After boil off the yarn has 49% BCE, 2.55 crimps per cm., 5.79% loop shrinkage and a filament crimp index of 19.25. Filaments of the yarn have a filament length different (FLD) of 6.7% with the filaments of the second yarn being longer than those of the first yarn.

The yarn is tufted into a level loop style carpet construction using a commercial nonwoven polypropylene primary backing and a 2,54 mm (one-tenth inch) tufter gauge 4,76 mm (three-sixteenths inch) pile height to give a carpet weight of 678 grams per square meter (20 ounces per square yard). The carpet is beck dyed with acid and cationic dyes to give a multicolor effect. The dyed carpet has an attractive random nondirectional heather-like coloration free of patterning and streaks.

Example 2

This example is similar to Example 1 except that the yarn polymer compositions and filament cross sections are different, thus providing different yarn aesthetics.

The first yarn is spun and drawn to provide 68 filaments of 21 dtex (19 denier) per filament of regular acid dyeable 66-nylon of bright luster and having a relative viscosity of 59 and 56±4 amine ends (eq./10^6 gm). The filaments have a trilobal cross section with a modification ratio of 2.3. The method is arranged as represented in Figure 2. A conventional lubicating aqueous yarn finish is applied to the cooled yarn prior to feed rolls 4 which are running at a surface speed of 689 meters/minute. Rolls 9 have a surface temperature of 170°C and a surface speed of 1950 meters/minute to draw the yarn 2.83×.

The second yarn is a 66-nylon cationic dyeable (80±8 sulfonate eq., 51.0 amine ends, 64 RV) semi-dull (0.15% titanium dioxide delusterant) continuous filament yarn which has been bulked at 2112 meters/min. from rolls heated to 220°C with a hot turbulent fluid by the method of U.S. Patent 3,854,177 using air at 230°C and at a pressure of 861 kPa (7.5 atm. gauge). The yarn is supplied from

the end of a stationary package held in a cre l at a position below draw rolls 9. The filaments have 4 continuous voids and a quadrilateral cross section as described in U.S. 3,745,961. Th second yarn has a nominal d nier f 1218 (135 tex) and contains 80 filaments. Before boil off the yarn has a t nacity of 2,74 dN/tex (3.11 grams/denier), elongation at break of 51%, an initial modulus of 7.05 and a cohesion of 3.70 cm. APDC. After boil-off th yarn has a denier of 1225 (136 tex), a t nacity of 2,60 dN/tex (2.95 g/den), elongation of 51%, modulus of 6.05, boil-off loop shrinkage of 4.08%, BCE 72%, crimp frequency 2.17 per centimeter, and filament crimp index 20.78.

Both yarns pass around draw rolls 9 with 9-1/2 wraps and are advanced to jet 18 which is of the type described in U.S. 3,638,291 (Yngve) which is supplied with air at 185°C at 1033 KPa (9.2 atm. gauge) pressure. The combined cobulked yarn is removed from the jet on a moving screen with a surface speed of 180.5 meters/minute and is held on the screen by a vacuum inside the drum. Filament cooling on the drum is aided by a water mist quench sprayed at a rate of 90 ml./min. Take-up roll 20 is running with a surface speed of 1768 meters/minute to remove the yarn from the screen and providing an overfeed between draw rolls 9 and take-up roll 20 of 10.3%. The yarn is wound up at 1834 meters/minute. The two yarns are kept separate from each other as they arrive at roll 9 by the position of guide 15. Tension on the second yarn between guide 15 and rolls 9 is 98 to 196 cN (100 to 200 grams) total 0,07 to 0,14 dn/tex; (0.08 to 0.16 grams per denier), the variation being due to variation in drag of yarn 10 across the surface of supply package 11. The filaments of both component yarns in the cobulked yarn have random, three-dimensional, curvilinear crimp with frequently alternating regions of S and Z filament twist.

The cobulked yarn contains 148 filaments and before boil-off has a denier of 2565 (285 tex), tenacity 2,37 dN/tex (2.68 grams/denier), 45% elongation, 7.15 modulus, cohesion of 3.30 cm, APDC. After boil-off the yarn has a tenacity of 2,2 dN/tex (2.50 grams/denier), 50% elongation, 4.63 modulus, 39.9% BCE, 5.86% loop shinkage, 2.09 crimps per cm., filament crimp index 17.08 and a filament length difference of 5.32% with the filaments of the cationic dyeable yarn being the longer.

The cobulked yarn is tufted into a level loop style carpet using a commercial nonwoven polypropylene primary backing, 3,2 mm (1/8 inch) gauge, 6,35 mm (1/4 inch) pile height to give a carpet weight of 814 g/m² (24 ounces per square yard). The carpet is dyed in a beck with multicolor acid and cationic dyes to give a yellow/orange-brown heather-like random mixed coloration and luster. The carpet has a pleasing nondirectional appearance.

The cobulked yarn is also tufted into a cut and loop pile mixed-lustre style carpet with the same type backing using 4,8 mm (3/16 inch) gauge, 19 mm (3/4 inch) cut and 6,35 mm (1/4 inch) loop pile height to give a carpet weight of 848 g/m² (25 ounces per square yard). The carpet is disperse dyed in a beck to a solid blue shade giving a carpet with a pleasing mixed lustre appearance instead of differential coloration.

Example 3

This example, of another preferred product, also employs a method as represented in Figure 2.

The first (spun-drawn) yarn is a 66-nylon cationic dyeable semi-dull continuous filament yarn containing 80 filaments per threadline of 16,7 dtex (15 denier) per filament and the second (creeled) yarn is a 66-nylon deep acid dyeable dead bright continuous filament bulked yarn containing 64 filaments per threadline of 21 dtex (19 denier) per filament. Process conditions are shown in Table I-A and polymer and yarn properties as listed in Table I-B.

Carpet construction specifications for a level loop tufted carpet made from the yarn are listed in Table I-C. The carpet has attractive random heather-like coloration when piece dyed in an acid and cationic dye solution. A carpet dyed in a reduced energy beck dye cycle dyes acceptably whereas a control carpet made from similar ambient air entangled yarns dyes nonuniformly and is unacceptably light in color.

TABLE I-A
Process specifications

Process variable	Cobulked proc ss	Creeled yarn component
Yarn Type	1225—854	1245—757A
Spin Block, T°C	292	290
Throughput per Hole g/m/s	2.9	4.1
Quench Air, T°C/RH%	5.0/80	10.0/80
Quench Air Flow (m^3/min.)	10.6	11.3
Primary Finish/Conc.	7%	8%
Finish Roll Speed, rpm	25	35
Feed Roll Speed, m/m	782	750
Draw Roll Wraps	9.5	9.5
Draw Roll, T°C	215	216
Draw Roll Speed m/m	2035	2174
Mech. Draw Ratio	2.6	2.9
Jet Type	X-Z*	D-I**
Jet Air Temp., °C	240	230
Jet Air Pressure (KPa; atm)	1175; 10.6	861; 7.5
Bulking Drum Speed (m/m)	95.8	77.8
Take-up Roll Speed (m/m)	1788	1820
Secondary Finish/Conc.	15%	20%
Mist Quench Flow Rate (ml/min.)	90	90
Wind-up Speed (m/m)	1898	1911
Wind-up Tension (N; g)	4,4; 450	2,7; 275

*As described and claimed in U.S. 3,638,291 (Yngve)
**As described and claimed in U.S. 3,525,134 (Coon)

TABLE I-B

Product before boil-off	Spun component	Creeled component	Cobulk d product
Relative Viscosity	49	64	N/A
Cross-section	*H.F.	H.F.	H.F.
Bundle tex (Denier)	136 (**1225)	140 (1256)	277 (2493)
Number of Filaments	80	64	144
Tenacity, dN/tex (gpd)	N/A	2,69 (3.05)	2,52 (2.86)
Elongation, %	"	51	51
Modulus	"	7.23	6.83
Cohesion (APDC), cm.	"	6.72	3.30
Dye Type	Cationic	Deep Acid	Cat./Dp. Acid
Luster	Semi-dull	Dead Bright	Semi-dull/ Dead Bright
Finish on Yarn (%)	N/A	1.16	.63
Product after boil-off			
Bundle tex (Denier)	136 (1255)	141 (1271)	282 (2539)
Number of Filaments	80	64	144
Tenacity, dN/tex (gpd)	N/A	2,46 (2.79)	2,42 (2.74)
Elongation, %	"	53	55
Modulus	"	5.51	4.76
Boil-Off Loop Shrinkage	"	4.02	5.62
Bundle Crimp Elongation	"	70.1	57.4
Crimp Frequency, cm.—1	"	3.94	2.68
Filament Crimp Index	"	18.15	15.42
Filament Length Difference, %	"	N/A	9.50
Polymer flake properties			
Type	854	757	
Relative Viscosity	34±3	40±3	
Amine Ends (NH_2)	40±4	82±4	
TiO_2, %	0.15	<.012	
Sulfonate Equivalents, SO_3	78±6	0.0	

*Hollow Filament (4-voids)
**Nominal Denier

TABLE I-C

Style	Level Loop
Tufter Gauge	(1/8") 3,2 mm
Pile Height	(1/4") 6,35 mm
Weight, (Oz./Yd.^{2}) g/m^2	(22.4) 759
Primary Backing	"Typar"
Secondary Backing	None
Dye Type	Heather Audit (Yellow, Orange Brown)
Dye Process	Beck

Example 4

This example is of a three-color yarn of the invention.

The first (spun-drawn) yarn is a 66-nylon light dyeable semi-dull continuous filament yarn containing 68 filaments of trilobal cross section per threadline having 22,7 dtex (20.4 denier) per filament; second and third yarns are combined in a process as generally shown in Figure 1. The second (creeled) yarn is a 66-nylon deep acid dyeable dead bright continuous filament bulked yarn containing 92 filaments per threadline of 6,0 dtex (5.4 denier) per filament. The third (creeled) yarn is a 66-nylon cationic dyeable dead bright continuous filament bulked yarn containing 92 filaments per threadline of 6,0 dtex (5.4 denier) per filament. Process specifications are as specified in Table II-A. Yarn and polymer properties are listed in Table II-B, and carpet construction specifications for a level loop carpet made from the yarn are listed in Table II-C. The carpet has attractive nondirectional random heather-like three-color aesthetic when piece dyed.

TABLE II-A

Process variable	Cobulked product	Creeled Yarn 1 (500—747)	Creeled Yarn 2 (500—744)
Spin Block, T°C	290	295	295
Throughput per Hole, g/m/s	2.68	0.70	0.62
Quench Air, T°C	6.1	12.8	12.8
Quench Air Flow	10.6	10.3	10.3
Primary Finish/Conc.	9%	10%	10%
Finish Roll Speed	27	28	25
Feed Roll Speed, m/m	450	786	695
Draw Roll Wraps	9	7.5	7.5
Draw Roll, T°C	210	210	212
Draw Roll Speed, m/m	1405	2432	2154
Mech. Draw Ratio	3.1	3.1	3.1
Jet Type	X-X	DI	DI
Jet Air Temp. °C	260	225	235
Jet Air Pressure (MPa; atm)	13,8; 135	12,7; 125	12,7; 125
Bulking Drum Speed (m/m)	56.3	70	70
Take-up Roll Speed (m/m)	1029	2084	1847
Secondary Finish/Conc.	15%	20%	20%
Mist Quench Flow (ml/min)	90	90	90
Wind-up Speed (m/m)	1113	2167	1920
Wind-up Tension (N; g)	2,70; 275	1,47; 150	1,47; 150

TABLE II-B

Product before boil-off	Spun-Drawn (1350—845)	Creeled Yarn 1 (500—747)	Cr eled Yarn 2 (500—744)	Cobulked Yarn L-4)
Modification Ratio	2.3	2.0	2.0	2.3/2.0
Bundle tex Denier)	150 *(1350)	53 (478)	57 (512)	251 (2258)
Number of Filaments	68	92	92	252
Tenacity, dN/tex (gpd)	N/A	3,27 (3.70)	2,11 (3.30)	2,40 (2.72)
Elongation	„	36	39	48
Modulus	„	12.38	10.58	6.48
Cohesion (APDC), cm.	„	7.05	5.60	2.23
Dye Type	Light Acid	Deep Acid	Cationic	Light/ Deep/Cat.
Luster	Semi-dull	Bright	Bright	Mixed
Finish on Yarn	N/A	0.90	0.90	0.46
Product after boil-off				
Bundle tex Denier)	158 (1423)	53,6 (482)	57,3 (516)	262 (2359)
Number of Filaments	68	92	92	252
Tenacity, dN/tex (gpd)	N/A	3,19 (3.61)	2,75 (3.12)	3,30 (2.61)
Elongation, %	„	39	41	53
Modulus	„	9.51	7.91	5.30
Boil-Off Loop Shrinkage	„	3.06	3.89	3.88
Bundle Crimp Elongation, %	„	50.0	50.0	45.0
Crimp Frequency, cm. —1	„	2.55	2.64	2.0
Filament Crimp Index	„	13.69	17.41	15.25
Filament Length Difference, %	„	N/A	N/A	13.4
Polymer flake properties				
Type	845	747	744	
Relative Viscosity	37	40.0	51.2	
Amine Ends (NH_2)	30	82.0	55.5	
TiO_2, %	0.15	<.012	<.012	
SO_3	0	0	80±8	

*Nominal Denier

TABLE II-C
Carpet construction

Style	Level Loop
Tufter Gauge	2,54 mm (1/10")
Pile Height	4,76 mm (3/16")
Weight, g/m² (Oz./Yd.²)	678 (20)
Primary Backing	"Typar"
Secondary Backing	None
Dye Type	Acid/Cationic
Color	Red/Green
Dye Process	Beck

Example 5

This example demonstrates the effects of creeled (second) yarn tension on yarn speeds and temperatures just prior to the bulking jet in a process of the invention. The process arrangement is substantially as represented in Figure 2 except that for tension control the second yarn is introduced into the process from a separate set of feed rolls to draw pins 5 and then a 6,35 mm (1/4 inch) pin is used to keep the first and second yarns separate from one another to facilitate measurement just prior to the bulking jet. The first and second yarn filament characteristics and the process conditions are substantially as described in Example 3. Yarn temperature measurements are taken 7,62 cm (3 inches) before the entrance to the bulking jet and yarn velocity measurements about 10,2 cm (4 inches) before the bulking jet. Yarn speed measurements are made using a Laser Doppler Velocimeter and yarn temperature measurements are made via a Barnes Infrared Micoline Scanner. Measurements are taken with the first yarn being produced at two different draw ratios, 2.0× and 3.0× and with creel yarn tensions adjusted over a range of 132,4 to 1324 cN/tex (150 to 1500 grams/denier) as measured just before the hot chest rolls. The temperature of these heated rolls is 215°C and their surface speed is 2300 ypm (2103 m/m). The results are summarized in Table III.

TABLE III-A
Draw ratio 3.0x

Yarn tension before hot chest	Spun live (first yarn) Temperature °C Low	Median	High	V locity YPM
1,47 N (150 gm)		205		2115
2,94 N (300 gm)				2115
4,90 N (500 gm)		203		2153
7,35 N (750 gm)				2134
9,80 N (1000 gm)	179	184	195	2162
12,26 N (1250 gm)				2186
14,7 N (1500 gm)	199	201	205	2115
	Draw ratio 2.0x			
1,47 N (150 gm)				2200
2,94 N (300 gm)				2223
4,90 N (500 gm)				2237
7,35 N (750 gm)				2148
9,80 N (1000 gm)	184	197	203	2209
12,26 N (1250 gm)				2237
14,7 N (1500 gm)				2233

TABLE III-A (cont.)
Draw ratio 3.0x

Yarn tension before hot chest	Spun live (first yarn) Range YPM	Spread YPM
7,42 N (150 gm)	1927—2350	(423)
2,94 N (300 gm)	1927—2280	(323)
4,90 N (500 gm)	1993—2312	(319)
7,35 N (750 gm)	1946—2327	(381)
9,80 N (1000 gm)	1951—2369	(418)
12,26 N (1250 gm)	2026—2369	(343)
14,7 N (1500 gm)	1951—2256	(305)

TABLE III-A (cont.)
Draw ratio 2.0x

Yarn tension before hot chest	Spun live (first yarn) Range YPM	Spread YPM
1,47 N (150 gm)	1998—2406	(409)
2,94 N (300 gm)	2054—2369	315
4,90 N (500 gm)	2059—2421	362
7,35 N (750 gm)	1983—2397	390
9,80 N (1000 gm)	2021—2397	376
12,26 N (1250 gm)	2092—2397	306
14,7 N (1500 gm)	2021—2444	423

TABLE III-A (cont.)
Draw ratio 3.0x

Yarn tension before hot chest	Creel (second yarn) Temperature °C Lowest	Median	Highest
1,47 N (150 gm)	118	135	156
2,94 N (300 gm)			
4,90 N (500 gm)	129	160	179
7,35 N (750 gm)			
9,80 N (1000 gm)	169	177	182
12,26 N (1250 gm)			
14,7 N (1500 gm)	179	179	185
Draw ratio 2.0x			
1,47 N (150 gm)			
2,94 N (300 gm)			
4,90 N (500 gm)			
7,35 N (750 gm)			
9,80 N (1000 gm)	168	188	197
12,26 N (1250 gm)			
14,7 N (1500 gm)			

TABLE III-A (cont.)
Draw ratio 3.0x

Yarn tension before hot chest	Creel (second yarn) Velocity YPM	Range YPM	Spread YPM	Difference in velocity of creel-line YPM
1,47 N (150 gm)	2195 (Modal) (2326) (Median)	2059—2604	(545)	80 (Modal) 211 (Median)
2,94 N (300 gm)	2275	2002—2538	(536)	160
4,90 N (500 gm)	2350	2112—2688	(576)	197
7,35 N (750 gm)	2247	1904—2627	(723)	113
9,80 N (1000 gm)	2153	1979—2397	(418)	−9
12,26 N (1250 gm)	2190	2007—2350	(343)	4
14,7 N (1500 gm)	2096	1904—2257	(352)	−19
		Draw ratio 2.0x		
1,47 N (150 gm)	2256	2139—2435	296	56
2,94 N (300 gm)	2256	2077—2421	343	33
4,90 N (500 gm)	2218	1974—2430	456	−19
7,35 N (750 gm)	2233	1974—2477	503	85
9,80 N (1000 gm)	2162	1857—2406	550	−47
12,26 N (1250 gm)	2049	1777—2374	597	−188
14,7 N (1500 gm)	2171	1951—2383	432	−62

The data show that the temperature of the second yarn is a function of its tension. At low tension, it has a low mean value and a large range, for example, at 1,47 N (150 gram) tension from 118°C to 156°C with a mean value of 135°C. As the tension increases to 14,7 N (1500 grams), the second yarn temperature reaches a steady state value of 180°C and its range is reduced to 179°C to 185°C. An explanation is that crimp in the yarn at lower tension inhibits contact with the surface of the hot rolls. The temperature of the first yarn when two ends of it are running and no creeled second yarn, is about 205°C with a narrow range of ±1°C. The temperature of the first yarn begins to vary as the tension of the second yarn increases over 9,80 N (1000 gram) tension. The speed of the second yarn is higher than the roll speed at 1,47 N to 14,7 N (150—500 grams) tension, possibly due to crimped straightening and removal of entanglement on the rolls. At higher tensions, the second yarn speed is reduced apparently as a result of increased stretch-related retraction.

Crimp frequencies after boil-off in the second yarn are higher than in the first yarn at creeled yarn tensions below 9,80 N (1000 grams). As creeled yarn tension is increased, crimp in the creeled yarn is pulled out and roll temperature is reduced due to increased loading, causing a reduction in crimp in both yarn components. Crimp variance in the second yarn is highest at the lowest creel tension. Crimp variance of the total yarn bundle follows a similar but less significant trend. Percent filament length difference decreases linearly with increased creeled yarn tension from 9.9% at 14,7 N (150 grams) to 0.1% at 14,7 N (1500 grams) in the 3.0x draw ratio process. In the 2.0x draw ratio process the retraction of the first yarn decreases and at second yarn tensions greater than 4,90 N (500 grams) the speed of the second yarn becomes less than that of the first yarn giving a percent FLD of about 0 and becoming negative at higher tensions. Bundle crimp elongation remains unexpectedly uniform over the entire series at both 3.0x and 2.0x. For the 3.0x draw ratio series, the effect of the creeled yarn tension on percent FLD and on dy -stepping (as discussed in detail in Exampl 6) are shown in Table III-B.

TABLE III-B

Creel tension (dN/tex; g/d)	% FLD	Modulus			Dye on fiber		
		Spun (T-854)	Creel (T-757A)	% Difference	Deep (%)	Cat (%)	Dye stepping
0,11; 0.12	9.9	8.37	6.84	22.3	—	—	—
0,22; 0.25	8.6	8.27	6.94	19.1	2.795	0.77	3.63
0,35; 0.40	7.2	8.37	7.76	7.8	2.68	0.655	4.09
0,53; 0.60	7.7	9.08	6.94	30.8	2.89	0.79	3.66
0,71; 0.80	3.3	8.37	7.04	18.9	2.795	0.87	3.21
0,90; 1.02	1.5	8.27	8.16	1.3	2.66	0.85	3.13
1,09; 1.24	0.1	8.37	8.06	3.8	2.185	0.885	2.47

Within method error, dye stepping with color index acid blue 40 appears to be independent of creel tension up to about 0,53 dN/t x (0.6 grams/denier). Then dye stepping appears to drop slowly in the range of about 0,71 to 0,88 dN/tex (0.8 to 1.0 grams/denier) and rapidly beyond 0,88 dN/tex (1.0 grams/denier).

Example 6

This example demonstrates the effect of the process of the invention under conditions substantially as used in Example 3 on dye stepping between various first and second yarns, both of 66-nylon, compared to the same yarn composition made by cold air intermingling of the same yarn component as taught in U.S. 4,059,873 (Nelson).

The dye used as C.I. Acid Blue 40, sold by Du Pont under the trade name "Merpacyl" Blue 2GA. An equivalent product is "Tectilon" Blue 2GA sold by Ciba-Geigy. Dyeings are carried out in a Model WBRG 3 "Vista-Matic" sample dyer made by Ahiba Apparatebau, Birsfelden, Switzerland. Five grams of yarn is wound on one of the stirring rods provided and prescoured with agitation for at least 20 minutes at 80°C in 200 ml. of an aqueous solution containing 1.0 grams/liter sodium perborate and 0.25 grams/liter "Igepon" T-51. The stirring rods are then removed from the dyer and the yarn rinsed first 5 times with tap water, then 5 more times with distilled water taking care to squeeze most of the excess liquid from the yarn after each rinse. The yarn is then stored while still on the stirring rod in a closed plastic bag to prevent it from drying out until it is dyed.

A calibration curve for the dye is established as follows; A stock solution of 0.25 g/L of the standardized dye in menol is prepared. Menol is a solvent for 66 nylon and consists of 85% phenol (redistilled from potassium carbonate in a nitrogen atmosphere) and 15% methanol (reagent grade). A reagent blank is prepared by dissolving 20 mg. of undyed 66-nylon yarn in 25 ml. menol. Four standard solutions are prepared by diluting 1, 2, 5 and 8 ml., respectively, of the stock solution with menol to 25 ml. To each standard solution is added 20 mg. of 66-nylon yarn. The absorbance of the 4 standard solutions at 630 nm is measured with a Bausch and Lomb "Spectronic" 21 spectrophotometer (Model DV) using Bausch and Lomb 10 mm. test tube cuvettes. The absorbence of the solvent is subtracted by first zeroing the instrument with a cuvette filled with the above reagent blank in the light path. The absorbences of the dye in the 4 solutions is, respectively, 0.095, 0.189, 0.474, and 0.756. From these the slope factor is calculated to be 9.454 L/g with a correlation coefficient of 0.999997.

Prescoured yarn samples are dyed for about 24 hours with agitation at room temperature (20—23°C) in 200 ml. of a dye bath containing 0.5 g/L dye and 5.0 g/L monosodium phosphate monohydrate. Before use, the pH of the dye bath is adjusted to 6.0 by adding NaOH solution as required. After dyeing, the yarn samples are removed from the dye baths, rinsed 5 times with tap water and 5 times with distilled water and then dried—while still wound on the stirring rods—for about 3 hours at 105°C. Portions of the dyed heather yarns are then separated into their components under a magnifying glass. The identity of the components is usually obvious. The only exception in this case are samples 8A and 8B where staining with a cationic dye was used to establish which of the two lighter dyeing components was the cat dyeable and which the light dyeable one.

Percent dye on fiber is then measured by dissolving about 20 mg. of fiber in 10 ml menol and measuring the absorbence at 630 nm as described above after zeroing the instrument with the reagent blank to subtract the absorbance of the solvent:

$$\% \text{ dye on fiber} = \frac{\text{absorbance} \times 1000}{9.454 \times \text{sample wt in mg.}}$$

Results are shown in Table IV. Col. 1 is the sample identification. Col. 2 identifies the components of the yarn by commercial type numbers to identify the type of polymer and filament cross section. LDR stands for 2.6x draw ratio—all others are drawn 3.0x. SB stands for steam bulked—all others are bulked with hot air. The underlined component in Col. 2 is the one which is spun during the process; the other component(s) is the creeled second yarn of the invention. For Sample 7D instead of intermingling, the two component yarns are wound side-by-side on the stirring rod; this is indicated by using the symbol+instead of /.

Col. 3 shows percent dye on fiber in the same order as the components shown in Col. 2. Some of the numbers are of single measurement; others are averages of 2 or more measurements. Samples 1C, 3C, and 4C could not be separated into their respective components because no shade difference could be detected. In these three cases, the total yarn was analyzed for dye on fiber and the value given is the average of the two components.

In all cases, the process of the invention unexpectedly results in less dye on fiber in the spun component and, with one exception, more dye on fiber in the creeled component. The one exception represents a steam bulked deep dyeable yarn which apparently is already so dyeable that rebulking it does not seem to have any effect.

Col. 4 shows dye-on-fiber of the second item of Col. 3 divided by dye-on-fiber of the first item given in Col. 3. In the case of Samples 8A and 8B the two numb rs given are dye-on-cat yarn divided

by dye-on-light and dye-on-deep yarn divided by dye-on-light, respectively. Note that this ratio in Col. 4 which is a direct measure of dye stepping is greater for Sample 1A (spun cat, creeled regular) than for Sample 2B (comingled cat and deep). Also, the ratio for Sample 3A (spun light, creeled regular) is greater than for Sample 5B (comingled light and deep).

Col. 5 shows the ratio for the A sample (produced by the process of the invention) divided by the ratio for the corresponding B sample (produced by simple air comingling). This value shown in col. 5 then is the factor by which dye stepping is enhanced by the process of the invention. Although the enhancement values shown have a high variability, analysis of variance shows that the variability can be attributed almost completely to the variability of the dye-on-fiber values.

TABLE IV
Dye-on-fiber-C.I. acid blue 40

1 Sample	2 Composition	3 Dye-on-fiber	4 Dye stepping	5 Enhancement
1A	754/756	0.41/2.00	4.88	
1B	754/756	0.49/1.86	3.90	1.28
1C	754/756	1.10 avg.	≤2	
2A	754/757	0.29/2.41	8.31	
2B	754/757	0.56/2.26	4.04	2.06
2C	754/757	0.60/2.05	3.42	
3A	755/756	0.51/2.48	4.86	
4B	755/556	0.76/1.79	2.36	2.06
3C	755/756	1.28 avg.	≤2	
4A	755/757	0.68/2.51	3.69	
5B	755/757	0.81/2.22	2.74	1.35
4C	755/757	1.48 avg.	≤2	
5A	744/747	0.60/1.72	2.86	1.20
6B	744/747	0.61/1.45	2.38	
6A	754/757LDR	0.38/3.05	8.03	1.65
3B	754/757LDR	0.54/2.63	4.87	
7A	754SB/757SB	0.52/3.10	5.96	1.23
7D	754SB+757SB	0.65/3.15	4.85	
8A	744/755/747	0.73/0.56/3.20	1.27/4.95	1.31/1.20
8B	744/755/747	0.69/0.71/2.93	0.97/4.13	
			avg.	1.48±0.35

Claims

1. A method of producing a composite cobulked continuous filament yarn containing filaments of a first oriented continuous filament yarn and of a second oriented continuous filament yarn in which the filaments of said second yarn are longer than the filaments of said first yarn said method including the steps of (1) feeding said first yarn in an undrawn state at a controlled speed to a pair of heated draw

rolls, (2) wrapping said first yarn around said draw rolls a sufficient number of times to avoid slippage thereon and said rolls being driven at a surface speed at least twice the feeding speed of said first yarn thereby applying tension to and drawing to molecularly orient said first yarn, (3) also feeding to said pair of draw rolls from a yarn package at a tension of less than 1.0 grams per denier said second yarn having a lower shrinkage potential in a hot gas bulking jet than said first yarn, (4) wrapping said second yarn around said draw rolls to prevent slippage thereon, (5) bringing said first and second yarns together and forwarding the combined yarns in a high velocity stream of hot turbulent fluid in a confined spaced which randomly crimps and entangles the filaments thereof and thereby forms a composite cobulked yarn in which the filaments of said second yarn are from about 4% to about 20% longer than the filaments of said first yarn, (6) removing the cobulked yarn from the stream of hot fluid and cooling it at low tension while the filaments are in a crimped condition to set crimp in the filaments and (7) winding the cobulked yarn into a package under tension, said method characterized by feeding to said draw rolls as said second yarn a heat-relaxed yarn containing crimped filaments which filaments are differentially dyeable with respect to the filaments of said first yarn and which filaments constitute from about 25% to about 75% of the total denier of the cobulked yarn.

2. A method of claim 1 wherein the feeding tension on said second yarn is less than about 0,71 dN/tex (0.8 grams per denier), the differential change in length between said first yarn and second yarn in the cobulking step is such that in the cobulked yarn the filaments of said second yarn are from 4% to 10% longer than the filaments of said first yarn, and the second yarn has been previously heat-relaxed and crimped in a hot fluid jet-bulking process.

3. A method of claim 1 or claim 2 wherein the cobulked yarn consists essentially of said first and second yarns with each yarn constituting at least about 1/3 of the denier of the cobulked yarn.

4. The method of claim 1, 2, or 3 wherein said first yarn is fed to the draw rolls directly from a zone in which the undrawn filaments are formed by melt-spinning.

5. A method of any one of claims 1 to 4 wherein the polymer of said first yarn is a polyamide and contains cationically dyeable sulfonate dye sites and the polymer of said second yarn is an acid-dyeable polyamide and contains greater than 50 equivalents of amine and groups per 10^6 grams of polymer.

6. A composite cobulked continuous filament yarn containing a first oriented continuous multifilament yarn which has been bulked in a hot fluid jet process simultaneously with a second oriented continuous multifilament yarn, the filaments of both yarns being randomly intermingled throughout the length of the composite yarn and having random three-dimensional curvilinear filament crimp with frequently alternating regions of S and Z filament twist, the filaments of said second yarn being from about 4% to about 20% longer in said composite yarn than the filaments of said first yarn, characterized in that the filaments of said first and second yarns are of polymers containing the same type of chemical dye sites with the filaments of said second yarn having a substantially greater concentration of said dye sites in equivalents per unit weight of polymer than the filaments of said first yarn to provide differential dyeability, and the filaments of said first yarn and of said second yarn each comprise from about 25% to about 75% of the total denier of said composite yarn.

7. A yarn of claim 6 wherein the filaments of said second yarn are from 4 to 10% longer than the filaments of said first yarn and the polymers of said first and second yarns are polyamides and said chemical dye sites are amine end groups.

8. A yarn of claim 6 or claim 7 wherein said first yarn is a cationically dyeable polyamide yarn.

9. A yarn of any one of claims 6 to 8 wherein the polymer of said first yarn is a polyamide which contains at least about 50 equivalents per 10^6 grams of cationically dyeable sulfonate dye sites and the polymer of said second yarn is a polyamide which contains at least about 50 equivalents per 10^6 grams of amine end groups.

10. A yarn of any one of claims 6 to 9 wherein the filaments of said first yarn have a substantially lower crimp frequency and a substantially greater tenacity and toughness than filaments of said second yarn.

11. A yarn of any one of claims 6 to 10 in which the ratio of dye concentration in filaments of said second yarn to filaments of said first yarn when dyed competitively with C.I. Acid Blue 40 is greater than 5.0.

12. A carpet containing a differentially dyeable or dyed pile yarn characterized in that the yarn is a composite yarn of any one of Claims 6 to 11.

Revendications

1. Un procédé de production d'un fil composite de filaments continus co-gonflés contenant des filaments d'un premier fil de filaments continus orienté et d'un second fil de filaments continus orienté dans lequel les filaments du second fil sont plus longe que les filaments du premier fil, ce procédé comprenant les étapes selon lesquelles (1) on fait arriver le premier fil dans un état non étiré à une vitesse réglée à une paire de cylindres d'étirage chauffés, (2) on fait passer ce premier fil autour des cylindres d'étirage un nombre de fois suffisant pour éviter un glissement sur eux, ces cylindres étant entraînés à une vitesse sup rfici lle au moins d ubl d là vitesse d'introduction du premier fil de façon à

appliquer une tension à ce premier fil et à l'étirer pour l'orienter moléculairement, (3) on fait arriver aussi à la paire de cylindres d'étirage à partir d'un paqu t de fil à un tension de moins de 1,0 gramme par denier le second fil ayant un potentiel de contraction dans un jet de gonflement par gaz chaud inférieur à celui du premier fil, (4) on fait passer le second fil autour des cylindres d'étirage de façon à empêcher un glissement sur eux, (5) on assemble le premier fil et le second et on fait avancer les fils combinés dans un courant à grande vitesse d'un fluide turbulent chaud dans un espace confiné, ce qui frise au hasard et enchevêtre leurs filaments et forme ainsi un fil composite co-gonflé dans lequel les filaments du second fil sont plus longs d'environ 4% à environ 20% que les filaments du premier fil, (6) on enlève le fil co-gonflé du courant de fluide chaud et on le refroidit à une faible tension tandis que les filaments sont dans un état frisé afin de fixer la frisure dans les filaments et (7) on enroule le fil co-gonflé en un paquet sous tension, ce procédé étant caractérisé en ce qu'on fait arriver aux cylindres d'étirage comme second fil un fil ayant subi une relaxation à chaud contenant des filaments frisés, filaments qui sont teintables de manière différentielle par rapport aux filaments du premier fil et qui constituent d'environ 25% à environ 75% du titre total en deniers du fil co-gonflé.

2. Un procédé selon la revendication 1, dans lequel la tension à laquelle on fait arriver le second fil est inférieure à environ 0,71 dN/tex (0,8 gramme par denier), le changement différentiel de longueur entre le premier fil et le second fil dans l'étape de gonflement simultané est tel que dans le fil co-gonflé les filaments du second fil sont plus longs de 4% à 10% que les filaments du premier fil, et le second fil a été préalablement relâché à chaud et frisé dans un procédé de gonflement par jet de fluide chaud.

3. Un procédé selon la revendication 1 ou la revendication 2, dans lequel le fil co-gonflé est constitué essentiellement du premier fil et du second fil, chaque fil constituant au moins environ 1/3 du titre en deniers du fil co-gonflé.

4. Un procédé selon la revendication 1, 2 ou 3, dans lequel on fait arriver le premier fil aux cylindres d'étirage directement à partir d'une zone dans laquelle les filaments non étirés sont formés par filage à l'état fondu.

5. Un procédé selon l'une quelconque des revendications 1 à 4, dans lequel le polymère du premier fil est un polyamide et contient des sites de coloration sulfonate teintables cationiquement et le polymère du second fil est un polyamide teintable par colorants acides et contient plus de 50 équivalents de groupes terminaux amines par 10^6 grammes de polymère.

6. Un fil composite de filaments continus gonflés ensemble contenant un premier fil de filaments multiples orienté qui a été gonflé dans un procédé à jet de fluide chaud simultanément avec un second fil à filaments multiples continus orienté, les filaments des deux fils étant entremêlés au hasard sur toute la longueur du fil composite et ayant un frisure de filaments curviligne tridimensionnelle statistique avec des régions alternant fréquemment de torsion S et Z des filaments, les filaments du second fil étant plus longs d'environ 4% à environ 20% dans le fil composite que les filaments du premier fil, caractérisé en ce que les filaments du premier fil et du second fil sont formés de polymères contenant le même type de sites de coloration chimique, les filaments du second fil ayant une concentration sensiblement plus forte de ces sites de coloration en équivalents par poids unitaire de polymère que les filaments du premier fil de façon à donner une susceptibilité tinctoriale différentielle, et les filaments du premier fil et du second fil constituent chacun d'environ 25% à environ 75% du titre en deniers total du fil composite.

7. Un fil selon la revendication 6, dans lequel les filaments du second fil sont plus longs de 4% à 10% que les filaments du premier fil et les polymères du premier fil et du second sont des polyamides et les sites de coloration chimique sont des groupes terminaux amines.

8. Un fil selon la revendication 6 ou 7, dans lequel le premier fil est un fil de polyamide teintable cationiquement.

9. Un fil selon l'une quelconque des revendications 6 à 8, dans lequel le polymère du premier fil est un polyamide qui contient au moins environ 50 équivalents par 10^6 grammes de sites de coloration sulfonates teintables cationiquement, et le polymère du second fil est un polyamide qui contient au moins environ 50 équivalents par 10^6 grammes de groupes terminaux amines.

10. Un fil selon l'une quelconque des revendications 6 à 9, dans lequel les filaments du premier fil ont une fréquence de frisure sensiblement inférieure et une ténacité et une résistance sensiblement supérieures à celles des filaments du second fil.

11. Un fil selon l'une quelconque des revendications 6 à 10, dans lequel le rapport de la concentration du colorant dans les filaments du second fil à celle dans les filaments du premier fil quand ils sont teints compétitivement avec C.I. Acid Bleue 40 est supérieur à 5.0.

12. Une tapis contenant un fil de poil teint ou teintable de manière différentielle, caractérisé en ce que le fil est un fil composite selon l'une quelconque des revendications 6 à 11.

Patentansprüche

1. Verfahren zur Herstellung eines ko-gebauschten Filament-Verbundgarnes, enthaltend Filamente eines ersten orientierten Filamentgarnes und eines zweiten orientierten Filamentgarnes, in welchem die Filamente des zweiten Garnes länger als die Filamente des ersten Garnes sind, welches die Stufen einschliesst (1) Zuführen des erst n Garnes in einem unverstreckten Zustand bei kontrol-

lierter Geschwindigkeit zu einem beheizten Abzugswalzenpaar, (2) Herumführen des rsten Garnes um die Abzugswalzen in einer genügenden Zahl von Umschlingungen, um Schlupf zu vermeiden, wobei die Walzen mit einer Oberflächeng schwindigkeit von mind stens d m Zweifachen der Zuführungsgeschwindigk it d s rst n Garnes angetrieben werden und dadurch Spannung an das erste Garn angelegt und dieses unt r molekularer Orienti rung verstreckt wird, (3) ausserdem dem Abzugswalzenpaar von einer Garnpackung bei einer Spannung von weniger als 1,0 g/den das zweite Garn von einem niedrigeren Schrumpfpotential in einer Heissgas-Bauschdüse als das erste Garn zuführen, (4) das zweite Garn um die Abzugswalzen herumführen, um Schlupf zu verhindern, (5) das erste und zweite Garn zusammenbringen und die vereinigten Garne in einem Strom von heissem turbulentem Fluid von hoher Geschwindigkeit in einen begrenzten Raum fördern, wodurch die Filamente regellos gekräuselt und verwirrt werden und ein kogebauschtes Verbundgarn gebildet wird, in welchem die Filamente des zweiten Garnes um etwa 4% bis etwa 20% länger als die Filamente des ersten Garnes sind, (6) das kogebauschte Garn aus dem Strom des heissen Fluids entfernen und es bei niedriger Spannung kühlen, während die Filamente in gekräuseltem Zustand vorliegen, um die Kräuselung in den Filamenten zu fixieren, und (7) das ko-gebauschtes Garn unter Spannung auf einen Wickel aufnehmen, dadurch gekennzeichnet, dass man den Abzugswalzen als zweites Garn ein wärmeentspanntes Garn zuführt, das gekräuselte Filamente enthält, die unterschiedlich anfärbbar in bezug auf die Filamente des ersten Garnes sind und etwa 25% bis etwa 75% des Gesamttiters des ko-gebauschten Garnes ausmachen.

2. Verfahren nach Anspruch 1, bei welchem die Zuführspannung des zweiten Garnes weniger als etwa 0,71 dN/tex (0,8 g/den) beträgt und der Unterschied der Längenänderung zwischen dem ersten Garn und dem zweiten Garn in der Stufe der Ko-Bauschung ein solcher ist, dass die Filamente des zweiten Garnes im ko-gebauschten Garn um 4% bis 10% länger als die Filamente des ersten Garnes sind und das zweite Garn zuvor wärmeentspannt und in einem Düsenbauschverfahren mit heissem Fluid gekräuselt ist.

3. Verfahren nach Anspruch 1 oder 2, bei welchem das ko-gebauschte Garn im wesentlichen aus den ersten und zweiten Garnen besteht, wobei jedes Garn mindestens etwa 1/3 des Titers des kogebauschten Garnes ausmacht.

4. Verfahren nach Anspruch 1, 2 oder 3, bei welchem das erste Garn den Abzugswalzen direkt aus einer Zone zugeführt wird, in welcher die unverstreckten Filamente durch Schmelzspinnen gebildet werden.

5. Verfahren nach einem der Ansprüche 1 bis 4, bei welchem das Polymer des ersten Garnes ein Polyamid ist und kationisch anfärbbare Sulfonatfärbestellen enthält und das Polymer des zweiten Garnes ein säureanfärbbares Polyamid ist und mehr als 50 Äquivalente Aminendgruppen je 10^6 g Polymer enthält.

6 Ko-gebauschtes Filament-Verbundgarn, enthaltend ein erstes orientiertes Multifilamentgarn, das in einem Düsenbauschverfahren mit heissem Fluid gleichzeitig mit einem zweiten orientierten Multifilamentgarn bebauscht worden ist, wobei die Filamente beider Garne über die Länge des Verbundgarnes regellos vermengt sind und regellos eine dreidimensionale, krummlinige Filamentkräuselung mit häufig alternierenden Regionen von S- und Z-Filamentdrall aufweisen und die Filamente des zweiten Garnes um etwa 4% bis etwa 20% länger als die Filamente des ersten Garnes sind, dadurch gekennzeichnet, dass die Filamente der ersten und zweiten Garne aus Polymeren bestehen, die den gleichen Typ von chemischen Färbestellen enthalten, und die Filamente des zweiten Garnes eine wesentlich grössere Konzentration an Färbestellen, ausgedrückt in Äquivalenten je Gewichtseinheit Polymer, als die Filamente des ersten Garnes haben, um eine unterschiedliche Anfärbbarkeit zu ergeben, und die Filamente des ersten Garnes und des zweiten Garnes jeweils etwa 25% bis etwa 75% des Gesamttiters des Verbundgarnes ausmachen.

7. Garn nach Anspruch 6, in welchem die Filamente des zweiten Garnes um 4 bis 10% länger als die Filamente des ersten Garnes sind und die Polymeren der ersten und zweiten Garne Polyamide und die chemischen Färbestellen Aminendgruppen sind.

8. Garn nach Anspruch 6 oder 7, in welchem das erste Garn ein kationisch anfärbbares Polyamidgarn ist.

9. Garn nach einem der Ansprüche 6 bis 8, in welchem das Polymer des ersten Garnes ein Polyamid ist, welches mindestens etwa 50 Äquivalente je 10^6 g kationisch anfärbbare Sulfonatfärbestellen enthält, und das Polymer des zweiten Garnes ein Polyamid ist, welches mindestens etwa 50 Äquivalente je 10^6 g Aminendgruppen enthält.

10. Garn nach einem der Ansprüche 6 bis 9, in welchem die Filamente des ersten Garnes eine wesentlich niedrigere Kräuselfrequenz und eine wesentlich höhere Festigkeit und Zähigkeit als die Filamente des zweiten Garnes haben.

11. Garn nach einem der Ansprüche 6 bis 10, in welchem das Verhältnis der Farbstoffkonzentration in den Filamenten des zweiten Garnes zu den Filamenten des ersten Garnes, wenn diese konkurrierend mit C.I. Acid Blue 40 angefärbt sind, grösser als 5,0 ist.

12. Teppich, enthaltend ein unterschiedlich anfärbbares oder angefärbtes Polgarn, dadurch gekennzeichnet, dass das Garn ein Verbundgarn nach einem der Ansprüche 6 bis 11 ist.

FIG. 1

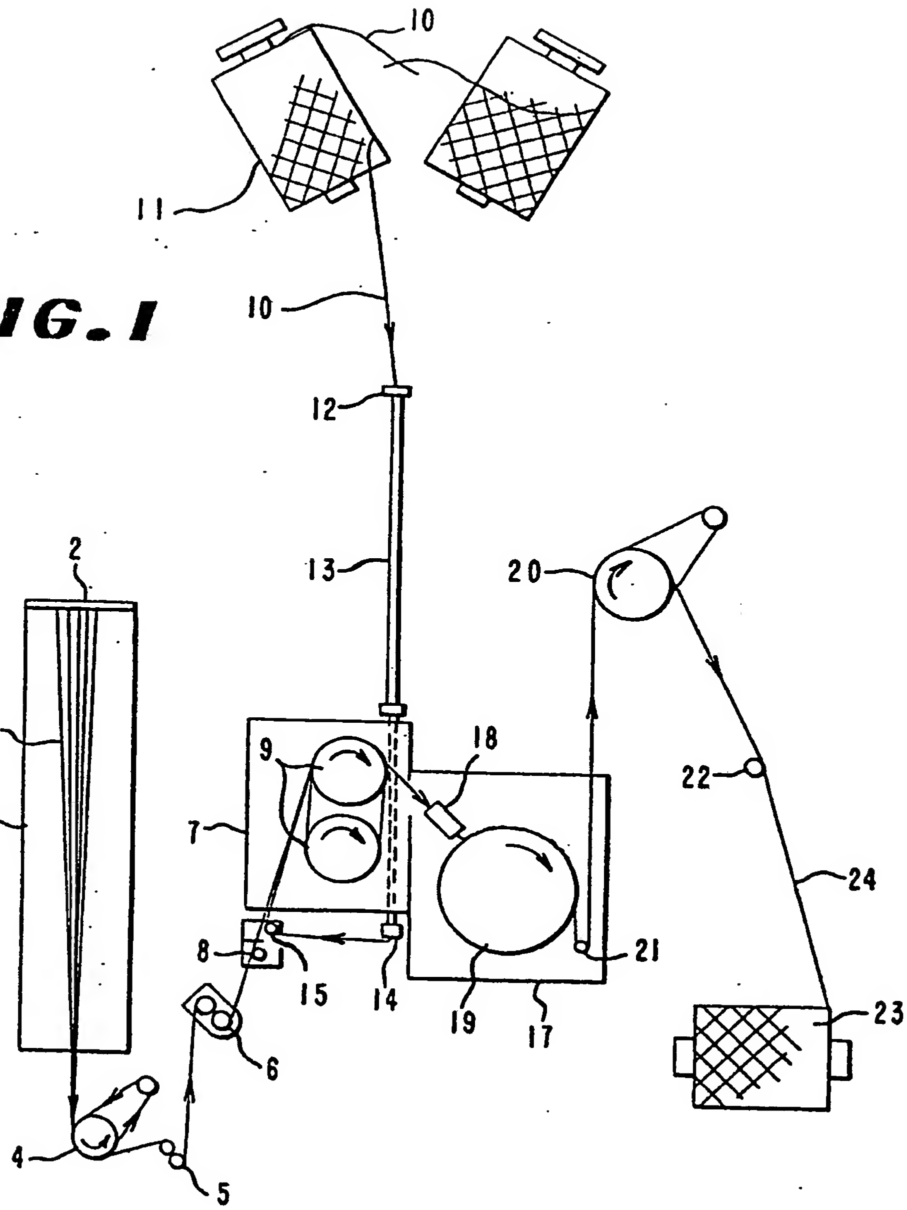

FIG. 2